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Nutritional value of dual-purpose wheat genotypes pastures under grazing by dairy cows

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ABSTRACT. In the south of Brazil, one of the major limitations to milk production is the low forage availability during autumn and early winter. The use of dual-purpose wheat genotypes is one alternative to minimize the impact of low forage availability in addition to produce grains. Therefore, this study aimed to evaluate the nutritional value of two dual-purpose wheat genotypes (BRS Tarumã and BRS Umbu). Structural composition and forage nitrogen uptake were evaluated. The nutritional value of the forage was analyzed for mineral matter (MM), organic matter (OM), neutral detergent fiber (NDF), crude protein (CP), total digestible nutrients (TDN), *in situ* organic matter digestibility (ISOMD) and *in situ* dry matter digestibility (ISDMD). Differences in NDF (49.03 vs. 46.44%), CP (24.4 vs. 27.4%), ISOMD (83.53 vs. 85.45%), ISDMD (83.59 vs. 86.65%) and TDN (75.37 vs. 78.39) for BRS Umbu and BRS Tarumã genotypes were detected, respectively. The BRS Umbu genotype had a lower leaf blade proportion and forage nitrogen uptake. The dual-purpose wheat genotype BRS Tarumã was superior in nutritive value.

Keywords: winter cereal, digestibility, nitrogen uptake, crude protein, *Triticum aestivum*.

Valor nutricional da forragem de genótipos de trigo de duplo propósito submetidos ao pastejo com vacas em lactação

RESUMO. Na Região Sul do Brasil, uma das grandes limitações da pecuária leiteira é a escassez de forragem que normalmente ocorre no período compreendidio entre o outono e início do inverno. O cultivo de genótipos de trigo de duplo propósito é uma das alternativas para minimizar o impacto da carência de forragem e ainda produzir grãos. Assim, esta pesquisa teve como objetivo avaliar o valor nutritivo de dois genótipos de trigo de duplo propósito (BRS Tarumã e BRS Umbu). O delineamento experimental foi o completamente casualizado, com dois tratamentos (genótipos), três repetições de área e medidas repetidas no tempo (pastejos). Para o pastejo foram utilizadas vacas em lactação da raça Holandesa, recebendo complementação alimentar de 1 kg de concentrado para cada 5 litros de leite. Nos 108 dias experimentais foram conduzidos três ciclos de pastejo. Avaliou-se a composição estrutural do pasto e a extração de nitrogênio da forragem. O valor nutricional foi avaliado quanto aos teores de matéria mineral (MM), matéria orgânica (MO), fibra em detergente neutro (FDN), proteína bruta (PB), nutrientes digestíveis totais (NDT), digestibilidade *in situ* da matéria orgânica (DISMO) e digestibilidade *in situ* da matéria seca (DISMS). Houve diferença para a FDN (49,03 vs. 46,44%), PB (24,4 vs. 27,4%), DISMO (83,53 vs. 85,45%), DISMS (83,59 vs. 86,65%) e NDT (75,37 vs. 78,39) para os genótipos BRS Umbu e BRS Tarumã, respectivamente. Valores similares foram encontrados para MM (10,34%) e MO (89,66%). O genótipo BRS Umbu apresenta menores participações de lâminas foliares na massa de forragem do pasto e menor extração de nitrogênio da massa de forragem. O genótipo BRS Tarumã apresenta melhores resultados quanto ao valor nutricional da forragem, participação de lâminas foliares e extração de N.

Palavras-chave: cereais de inverno, digestibilidade, extração de nitrogênio, proteína bruta, *Triticum aestivum*.

Introduction

During autumn and early winter, the southern region of Brazil is characterized by an expected decline in forage yield and nutritive value of pastures. At that time, summer species decrease its production and winter species, such as ryegrass, are not yet fully grown. In this context, the use of winter cereal grains may contribute to minimize feed deficit through the production of high quality forage early in the growing season (Hahn, Mühl, Feldmann, Werlang, & Hennecka, 2015).

When grown with dual purpose (forage production and grains), these cereals maximize the use of land, infrastructure, machinery and labor, diversifying and improving the distribution of farm incomes. In addition, they allow greater flexibility, since the farmer may choose to produce grains rather than animals and vice-versa according to climatic conditions or prices (Pitta et al., 2011).

Among the dual-purpose cereals, wheat (*Triticum aestivum* L.), usually cultivated for grain production, can be used as forage source during the vegetative period (Martin et al., 2010). Embrapa Wheat (Passo Fundo, Rio Grande do Sul State, Brazil) has selected several dual-purpose cultivars (BRS Guatambu, BRS Figueira, BRS Tarumã and BRS Umbu). Among these cultivars, the BRS Umbu genotype has been highlighted by its high grain yield, while BRS Tarumã has shown a more balanced forage and grain production (Meinerz et al., 2012).

The dual-purpose wheat genotypes are characterized by producing high-quality forage. However, studies comparing the forage nutritive value of these cultivars submitted to grazing are scarce. In this context, the evaluation of forage quality traits of these genotypes is fundamental to choose the most suitable cultivar to be used under grazing in the dual-purpose management.

The aim of this study was to evaluate the nutritional value, forage mass and composition, disappearance of forage and forage nitrogen uptake of two dual-purpose wheat genotypes - BRS Tarumã and BRS Umbu under grazing.

Material and methods

The trial was performed from April to October 2014 at the Federal University of Santa Maria (UFSM), Santa Maria - RS, Brazil, located in the central depression of Rio Grande do Sul, latitude 29º43 'S and longitude 53º42' W. The soil is classified as sandy Dystrophic Red Argisol. According to the classification of Köppen, the climate is humid subtropical (Kuinchtner & Buriol, 2001). The temperature and precipitation averages during the trial were 17.34°C and 194.28 mm, higher than the climate normals for the region (15.76 and 140.51 mm - figure 1).

The experimental area of 4380 m^2 was divided into six paddocks. The treatments consisted of two dual-purpose wheat genotypes: BRS Tarumã and BRS Umbu, under grazing by lactating cows. The experimental design was a completely randomized design with two treatments (genotypes) and three repetitions (paddocks) with three measures repeated over time (grazing cycles).

Acidity correction and soil fertilization were performed based on soil chemical analysis and crop requirements. Soil analysis data were as follows: pH in water = 5.06; SMP index = 5.6; P = 7.9 mg dm^{-3}; K = 114 mg dm^{-3}; Al^{3+} = 0.5 $cmol_c$ dm^{-3}; Ca^{2+} = 6.1 $cmol_c$ dm^{-3}; Mg^{2+} = 3.3 $cmol_c$ dm^{-3}; OM = 3.8%; base saturation = 59.73% and Al saturation = 6.33% (analyzes were carried out by the Soil Analysis Laboratory of the Federal University of Santa Maria). 5.4 tons ha^{-1} of dolomitic limestone were incorporated with a disc harrow 90 days before sowing. At sowing, 20 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1} were used. SMP method was used to determine soil lime requirement.

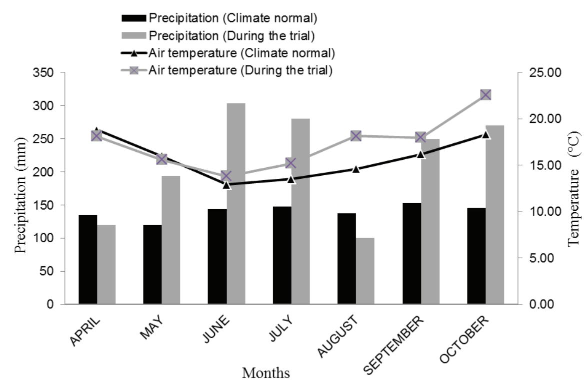

Figure 1. Precipitation and air temperature climate normals and during the trial (April to October).

The sowing was performed on April 17, 2014, in rows spaced 17 cm apart at a density of 400 viable seeds m^{-2}, with conventional soil preparation. Nitrogen fertilization, using urea, was done with 130 kg N ha^{-1}, divided equally in four applications. The first application was performed 30 days after sowing because of tillering, and the remaining after each grazing.

The criterion to begin grazing was the canopy height, between 25 and 30 cm, which corresponded to the beginning of stem elongation. The height measurement was done before the beginning and after each grazing cycle, with the aid of a grazing stick. The double sampling technique was used to collect pasture samples, with 20 visual estimates and 5 destructive sampling close to the ground. The disappearance of forage was obtained by the difference between the pre- and post-grazing pasture masses. The samples obtained in the pre- and post-grazing were homogenized and a sub-sample was removed to determine the structural components, separated manually in leaf, stem + sheath and senescent material. The samples were dried in an oven with forced air circulation at 55ºC until constant weight to determine the proportion of each component, according to the methodology adapted from Confortin et al. (2010).

Fifteen lactating Holstein cows, weighing on average 570 kg (±65.50 kg), were used for grazing. The mean productivity of the herd during the evaluation period was 19 kg milk d^{-1} (±5.61 kg). The rotational stocking management was used with one day of occupation. The cows were submitted to two daily milkings at 7:30 a.m. and at 4:00 p.m., remaining on wheat pastures from 9:00 a.m. to 3:30 p.m. and from 6:00 p.m. to 7:00 p.m. Cows were supplemented at 1 kg of concentrate for every 5 L of milk produced. The concentrate with 18% CP, 79% TDN, 1.7% phosphorus and 1.2% calcium was composed of wheat bran, soybean meal, corn and a vitamin and mineral premix. The NUTRIMAX software was used to formulate the concentrate and forage supply (6% of body weight) was used to determine the stocking rate. While wheat pastures were not being used, the cows were on oats-ryegrass pasture, receiving the same amounts of supplement.

To estimate the nutritive value of the forage, samples were collected in pre- and post-grazing using hand-plucking technique (Euclides et al., 1992). The samples were partially dried in an oven with forced air circulation at 55ºC and then ground in a Willey mill and packed in plastic bags. Subsequently, samples at the beginning and end of each grazing cycle were mixed. Analyzes of crude protein by the Kjeldahl method (Association Official Analytical Chemists [AOAC], 1997), neutral detergent fiber - NDF (Van Soest, Robertson, & Lewis, 1991), *in situ* dry matter digestibility – ISDMD and *in situ* organic matter digestibility - ISOMD (Mehrez & Orskov, 1977) were carried. The product between the percentage of organic matter and *in situ* organic matter digestibility divided by 100 obtained the estimation of total digestible nutrients (Barber, Adamson, & Altman, 1984). The amount of nitrogen extracted was calculated by the product between the disappearance of forage and the average nitrogen content in the forage mass obtained by the Kjeldahl method (Association Official Analytical Chemists [AOAC], 1997).

The data were submitted to analysis of variance by the Fisher-Snedecor's F test for comparison between the genotypes at 5% probability. The mean values of the grazing cycles were compared using Tukey's test at 5% probability using the MIXED procedure (SAS, 2016). The variables of forage mass and nutritive value were submitted to Pearson's correlation analysis. The mathematical model was used as follows: $Y_{ijk} = m + T_i + R_j(T_i) + P_k + (TP)_{ik} + \varepsilon_{ijk}$, in which: Y_{ijk} represents the dependent variables; m is the mean of all observations; T_i is the effect of treatments (genotypes); $R_j(T_i)$ is the repetition within the treatments (error a); P_k is the effect of grazing cycles; $(TP)_{ik}$ represents the interaction between treatments and grazing cycles; ε_{ijk} is the residual effect (error b).

Results and discussion

The forage mass in the pre-grazing for BRS Tarumã genotype was higher than BRS Umbu only in the second grazing cycle (Table 1). This difference was attributed to the higher leaf blade proportion during the trial period. Among grazing cycles, from the second to the third cycle, an increase in forage available was verified only for BRS Umbu genotype due to the higher stem + sheath proportion in this period.

Regarding the structural composition of the pastures, there was variability among the genotypes. Relative to the leaf blade fraction, the values were higher for BRS Tarumã genotype in all grazing cycles both in the initial and residual forage mass, confirming its prostrate growth habit and intense tillering (Martin et al., 2010). Mean values for the leaf blade proportion verified in this study are similar to those obtained by Meinerz et al. (2011) of 74.44 and 70.91% for BRS Tarumã and Umbu, respectively, when submitted to three cuts.

The high leaf blade proportion, as verified in the analyzed genotypes, is a desirable characteristic, because in addition to facilitate forage intake, the leaves represent the most nutritious fraction of the plant, influencing animal production under grazing. Complementary, the high leaf blade proportion is essential for pasture management, since this structure plays a fundamental role in the production of photoassimilates necessary to the growth, regrowth and maintenance of forage plants (Cutrim Junior, Cândido, Valente, Carneiro, & Carneiro, 2011).

For the stem + sheath fraction (pre-grazing), higher values were observed for BRS Umbu wheat as a result of its more erect growth habit compared to the BRS Tarumã (Martin et al., 2010), increasing stem + sheath proportion in the forage mass. Regarding the senescent material (pre-grazing), a similarity between the genotypes was found, with a natural increase in subsequent grazing as a function of the advancement of plant age.

Regarding the leaf blade/stem + sheath ratio, higher values were observed for BRS Tarumã wheat. This difference is related to the structural characteristics of the BRS Tarumã cultivar, which have a higher leaf blade proportion and a lower stem proportion in relation to BRS Umbu (Table 1). The leaf blade/stem + sheath ratio is an indicative of diet quality for animals under grazing, since the higher the proportion of leaves the greater the nutritive value of the pasture (Kirchner et al., 2010).

Among the grazing cycles, the leaf blade/stem + sheath ratio decreased in both genotypes due to the advancement of plant age. At that time, the internodes elongate, consequently increasing the number of stems in the forage mass. In grasses, this process induces an increase in stem proportion and a reduction in leaf proportion in the forage mass (Rocha et al., 2007). The mean values for leaf blade/stem + sheath (pre-grazing) ratio of 2.1 and 4.2 for BRS Umbu and BRS Tarumã, respectively, are similar to those verified by Kirchner et al. (2010), of 2.1 for black oats and 4.6 for white oats cv. Fapa 2 submitted to three cuts.

Table 1. Forage mass, disappearance of forage and forage nitrogen uptake of dual-purpose wheat genotypes under grazing by lactating cows. Santa Maria, 2014.

Genotype	Grazing cycles									
	1°	2°	3°	Mean	SEM	1°	2°	3°	Mean	SEM
	Pre-grazing					Post-grazing				
	Forage mass (t DM ha^{-1})									
BRS Umbu	1.55^{Aa}	1.46^{Ab}	1.59^{Ab}	1.54	32.05	0.65^{Ba}	0.78^{Ba}	0.93^{Aa}	0.79	33.08
BRS Tarumã	1.57^{Ba}	1.75^{Ba}	2.07^{Aa}	1.79	61.57	0.66^{Ba}	0.69^{Ba}	1.03^{Aa}	0.78	51.48
SEM	37.72	45.32	65.33	-	-	9.79	20.27	34.09	-	-
	Leaf blade (%)									
BRS Umbu	73.1^{Ab}	60.8^{Bb}	48.8^{Cb}	60.9^{b}	2.73	41.2^{Ab}	29.3^{Bb}	19.4^{Bb}	29.8^{b}	2.67
BRS Tarumã	83.1^{Aa}	76.2^{Ba}	58.7^{Ca}	72.7^{a}	2.60	58.1^{Aa}	38.6^{Ba}	29.8^{Ca}	40.2^{a}	2.76
SEM	1.56	1.99	1.69	-	-	2.20	1.58	2.70	-	-
	Stem + sheath (%)									
BRS Umbu	24.1^{Ba}	30.2^{Ba}	43.1^{Aa}	32.1^{a}	2.98	37.9^{Aa}	46.0^{Aa}	54.3^{Aa}	44.4	3.12
BRS Tarumã	13.0^{Bb}	17.4^{Bb}	25.9^{Ab}	18.8^{b}	1.35	28.5^{Aa}	38.8^{Aa}	39.6^{Aa}	35.6	1.51
SEM	1.45	1.71	3.12	-	-	1.67	1.95	3.42	-	-
	Senescent material (%)									
BRS Umbu	4.7^{Ba}	8.8^{Aa}	10.4^{Aa}	7.9	0.88	21.1^{Aa}	19.4^{Aa}	26.5^{Aa}	20.7	1.11
BRS Tarumã	3.7^{Ca}	6.3^{Ba}	15.4^{Aa}	8.5	1.32	15.5^{Ca}	22.5^{Ba}	29.8^{Aa}	22.6	1.54
SEM	0.65	0.50	0.92	-	-	1.35	0.75	1.32	-	-
	Leaf blade/Stem + sheath									
BRS Umbu	4.0^{Ab}	2.0^{Bb}	1.0^{Bb}	2.1^{b}	0.28	1.1^{Ab}	0.8^{Aa}	0.8^{Aa}	0.9	0.11
BRS Tarumã	6.8^{Aa}	4.4^{Ba}	2.3^{Ca}	4.2^{a}	0.43	1.9^{Aa}	1.0^{Ba}	0.7^{Ba}	1.2	0.13
SEM	0.42	0.30	0.16	-	-	0.12	0.06	0.12	-	-

Genotype	Grazing cycles			Mean	Total	SEM
	1°	2°	3°			
	Disappearance of forage (t DM ha^{-1})					
BRS Umbu	0.90^{Aa}	0.67^{Aa}	0.69^{Aa}	0.75	2.26^{b}	0.42
BRS Tarumã	0.91^{Aa}	1.05^{Aa}	1.04^{Aa}	1.00	3.00^{a}	0.52
SEM	0.41	0.61	0.68	-	0.59	-
	Forage nitrogen uptake (kg ha^{-1})					
BRS Umbu	34.93^{Aa}	28.41^{Aa}	24.91^{Ab}	29.41	88.25^{b}	1.62
BRS Tarumã	40.10^{Aa}	46.71^{Aa}	46.70^{Aa}	44.50	133.5^{a}	2.67
SEM	1.81	2.87	3.92	-	7.36	-

Means followed by the same letter, lowercase letter within column and uppercase letter within row, do not differ by Tukey's test at 5% probability.

For the disappeared of forage, higher values were found for the BRS Tarumã genotype considering total forage accumulation. This result may be associated with higher leaf blade proportion and better forage digestibility (Table 2), as well as the pasture structure. These factors contribute to increase dry matter intake in ruminants (Steinwandter et al., 2009).

Relative to the forage nitrogen uptake through the forage biomass consumed by the animals, higher uptake in BRS Tarumã genotype was verified considering the total forage mass removed. The highest uptake observed for BRS Tarumã wheat was a result of the higher leaf blade proportion (Table 1), since these structures contain higher concentrations of chlorophyll and enzymes, which have nitrogen as one of the main constituents (Viana & Kiehl, 2010). The superiority of this genotype relative to the synthesis of mineral N in organic compounds is highlighted, since both evaluated genotypes received the same nitrogen fertilization.

For the percentages of dry matter (DM), there was no difference between genotypes (Table 2). Among grazing cycles, there was an increase in DM content in the third cycle for BRS Tarumã, a condition attributed to the increase in senescent material (Table 1). For mineral matter (MM) and organic matter (OM), similarity was found between both genotypes and grazing cycles, with percentages close to 10 and 90% for MM and OM, respectively.

Regarding the NDF content, the values were similar during the first grazing but higher for BRS Umbu wheat in subsequent grazing cycles. This result is related to the high stem proportion (Table 1), which raises the amount of cell-wall material in forage. This condition is confirmed by the correlation between stem proportion and NDF ($r=0.64$, $P=0.0036$). The increase in NDF content during grazing for the two genotypes is the result of the advancement of plant age. This process reduces leaf proportion to the detriment of stems and senescent material, increasing the contents of cellulose, hemicellulose and lignin, which are the main NDF components (Macedo Júnior, Zanine, Borges, & Pérez, 2007). Moreira, Reis, Ruggieri, and Saran Junior (2007) reported mean values for NDF of 57.61 and 63.28% in the first and second grazing, respectively, for triticale sown on Sorghum-sudan straw grazed by lactating cows. Bartmeyer et al. (2011) obtained NDF contents of 45.54 and 62.66% when evaluating wheat cultivar BRS 176 under continuous stocking at 50 and 95 days after emergence, respectively.

Table 2. Nutritional value of dual-purpose wheat genotypes pastures under grazing by lactating cows. Samples collected using the hand-plucking technique. Santa Maria, 2014.

Genotype	Grazing cycles			Mean	SEM
	1	2	3		
		Dry matter (%)			
BRS Umbu	17.53^{A}	17.33^{A}	19.26^{A}	17.66	0.11
BRS Tarumã	15.25^{B}	16.20^{B}	19.80^{A}	17.46	0.33
SEM	0.30	0.26	0.03	-	-
		Mineral matter (%)			
BRS Umbu	10.37^{A}	10.63^{A}	8.15^{A}	11.37	0.32
BRS Tarumã	9.56^{A}	9.85^{A}	8.58^{A}	9.32	0.45
SEM	0.39	0.55	0.78	-	-
		Organic matter (%)			
BRS Umbu	89.62^{A}	89.36^{A}	91.84^{A}	88.62	0.71
BRS Tarumã	90.43^{A}	90.15^{A}	90.42^{A}	90.67	0.55
SEM	1.23	0.87	1.75	-	-
		Neutral detergent fiber (%)			
BRS Umbu	43.76^{B}	52.29^{Aa}	51.07^{Aa}	49.03	1.00
BRS Tarumã	43.63^{B}	48.70^{Ab}	46.98^{Ab}	46.44	0.54
SEM	0.36	0.54	0.55	-	-
		Crude protein (%)			
BRS Umbu	24.41^{AB}	26.32^{A}	22.51^{Bb}	24.41	0.50
BRS Tarumã	26.70^{A}	27.81^{A}	27.63^{Aa}	27.4	0.31
SEM	0.50	0.28	0.78	-	-
		In situ dry matter digestibility (%)			
BRS Umbu	87.04^{A}	84.64^{AB}	76.63^{Bb}	83.59	1.12
BRS Tarumã	87.55^{A}	84.95^{A}	87.39^{Aa}	86.63	0.63
SEM	0.76	1.24	0.81	-	-
		In situ organic matter digestibility (%)			
BRS Umbu	86.99^{A}	84.96^{AB}	79.08^{Bb}	83.53	1.22
BRS Tarumã	87.39^{A}	84.59^{A}	87.36^{Aa}	85.45	0.70
SEM	0.81	1.30	0.97	-	-
		Total digestible nutrients (%)			
BRS Umbu	77.97^{A}	75.92^{A}	72.27^{Ab}	75.37	1.21
BRS Tarumã	79.03^{A}	76.27^{A}	79.88^{Aa}	78.39	1.72
SEM	1.49	2.98	1.72	-	-

Means followed by the same letter, lowercase letter within column and uppercase letter within row, do not differ by Tukey's test at 5% probability.

BRS Tarumã genotype had a higher crude protein content in the third grazing cycle because of the maintenance of higher leaf blade proportion from tillers until the end of the evaluation period (Table 1). Considering the average of the three grazing cycles, the CP value observed for BRS Tarumã and BRS Umbu genotypes is higher than that obtained by Meinerz et al. (2011), who verified CP levels of 21.24 and 21.90% when studying the same genotypes submitted to three cuts, respectively. This difference is due to the lower nitrogen fertilization in relation to the present study.

Relative to the contents of ISDMD, ISOMD and TDN, higher values were obtained for BRS Tarumã wheat, in the third grazing cycle, keeping relation with the data obtained for protein. This result is attributed to the higher leaf blade proportion, lower stem proportion (Table 1) and, consequently, lower NDF content (Table 2). In addition, the longer growth cycle in relation to the BRS Umbu results in a longer tillering period, improving the nutritive value of the forage, since the increase in leaf proportion in the pasture mass maintains high levels of protein and digestibility (Hastenpflug et al., 2011). The mean ISDMD content for BRS Umbu wheat was higher than that found by Fontaneli et al. (2009) of 68.1%, for the same genotype subjected to only one cut.

The contents of ISDMD, ISOMD and TDN remained stable throughout the evaluation period for BRS Tarumã. For BRS Umbu, there was a decrease in the third grazing due to its short growth cycle (Hastenpflug et al., 2011), which, with the increase in ambient temperature, rapidly directs photoassimilates to structural tissue formation, preparing the plant for early flowering in relation to BRS Tarumã. This process implies an increase in tissue lignification and stem proportion in the forage mass, with consequent reduction of forage digestibility and energy (Moreira et al., 2007).

Conclusion

Pre-grazing forage mass and leaf blade proportion were higher for BRS Tarumã genotype. The leaf blade/stem + sheath ratio was lower for BRS Umbu wheat. The BRS Tarumã wheat had a higher nutritive value when compared to BRS Umbu. Large quantities of disappearance of forage and forage N uptake were obtained for BRS Tarumã genotype.

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References

Association Official Analytical Chemists [AOAC]. (1997). *Official Methods of Analysis* (16th ed.). Gaithersburg, US: AOAC.

Barber, W. P. B., Adamson, A. H., & Altman, J. F. B. (1984). New methods of feed evaluation. In: W. Haresign, & D. J. A. Cole (Eds.), *Recent advances in animal nutrition* (p. 161-176). London, UK: Butterworths.

Bartmeyer, T. N., Dittrich, J. R., Silva, H. A., Moraes, A., Piazzetta, R. G., Gazda, T. L., & Carvalho, P. C. F. (2011). Trigo duplo-propósito submetido ao pastejo de bovinos nos campos gerais do Paraná. *Pesquisa Agropecuária Brasileira*, *46*(10), 1247-1253.

Cutrim Junior, J. A. A., Cândido, M. J. D., Valente, B. S. M., Carneiro, M. S. S., & Carneiro, H. A. V. (2011). Características estruturais do dossel de capim-tanzânia submetido a três frequências de desfolhação e dois resíduos pós-pastejo. *Revista Brasileira de Zootecnia*, *40*(3), 489-497.

Confortin, A. C. C., Quadros, F. L. F., Rocha, M. G., Camargo, D. G., Glienke, C. L., & Kuinchtner, B. C. (2010). Morfogênese e estrutura de azevém anual submetido a três intensidades de pastejo. *Acta Scientiarum. Animal Sciences, 32*(4), 385-391.

Euclides, V. P. B., Macedo, M. C. M., Valle, C. B., Difante, G. S. Barbosa, R. A., & Cacere, E. R. (1992). Avaliação de diferentes métodos de amostragem (para se estimar o valor nutritivo de forragens) sob pastejo. *Revista Brasileira de Zootecnia*, *21*(4), 691-702.

Fontaneli, R. S., Fontaneli, R. S., Santos, H. P., Nascimento Junior, A., Minella, E., & Caierão, E. (2009). Rendimento e valor nutritivo de cereais de inverno de duplo propósito: forragem verde e silagem ou grãos. *Revista Brasileira de Zootecnia*, *38*(11), 2116-2122.

Hahn, L., Mühl, F. R., Feldmann, N. A., Werlang, L., & Hennecka, J. (2015). Gramíneas forrageiras anuais de inverno em cultivo estreme e em sobressemeadura em tifton 85. *Enciclopédia Biosfera*, *11*(21), 1159-1169.

Hastenpflug, M., Braida, J. A., Martin, T. N., Ziech, M. F., Simionatto, C. C., & Castagnino, D. S. (2011). Cultivares de trigo duplo propósito submetidos ao manejo nitrogenado e a regimes de corte. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, *63*(1), 196-202.

Kirchner, R., Soares, A. B., Sartor, L. R., Adami, P. F., Migliorini, F., & Fonseca, L. (2010). Desempenho de forrageiras hibernais sob distintos níveis de luminosidade. *Revista Brasileira de Zootecnia*, *39*(11), 2371-2379.

Kuinchtner, A., & Buriol, G. A. (2001). Clima do Estado do Rio Grande do Sul segundo a classificação climática de Köppen e Thornthwaite. *Disciplinarum Scientia*, *2*(1), 171-182.

Macedo Júnior, G. L., Zanine, A. M., Borges, I., & Pérez, J. R. O. (2007). Qualidade da fibra para a dieta de ruminantes. *Ciência Animal*, *17*(1), 7-17.

Martin, T. N., Simionatto, C. C., Bertoncelli, P., Ortiz, S., Hastenpflug, M., Ziech, M. F., & Soares, A. B. (2010). Fitomorfologia e produção de cultivares de trigo duplo propósito em diferentes manejos de corte e densidades de semeadura. *Ciência Rural*, *40*(8), 1695-1701.

Mehrez, A. Z., & Orskov, E. R. (1977). A study of the artificial fiber bag technique for determining the digestibility of feed in the rumen. *Journal of Agricultural Science*, *88*(1), 645-650.

Meinerz, G. R., Olivo, C. J., Fontaneli, R. S., Agnolin, C. A., Fontaneli, R. S., Horst, T., ... Debem, C. M. (2011). Valor nutritivo da forragem de genótipos de cereais de inverno de duplo propósito. *Revista Brasileira de Zootecnia*, *40*(6), 1173-1180.

Meinerz, G. R., Olivo, C. J., Fontaneli, R. S., Agnolin, C. A., Horst, T., & Debem, C. M. (2012). Produtividade de cereais de inverno de duplo propósito na depressão central do Rio Grande do Sul. *Revista Brasileira de Zootecnia*, *41*(4), 873-882.

Moreira, A. L., Reis, R. A., Ruggieri, A. C., & Saran Junior, A. J. (2007). Avaliação de forrageiras de inverno irrigadas sob pastejo. *Ciência e Agrotecnologia*, *31*(6), 1838-1844.

Pitta, C. R. S., Soares, A. B., Assmann, T. S., Adami, P. F., Sartor, L. R., Migliorini, F., … Assmann, A. L. (2011). Dual-purpose wheat grain and animal production under different grazing periods. *Pesquisa Agropecuária Brasileira*, *46*(10), 1385-1391.

Rocha, M. G., Quadros, F. L. F., Glienke, C. L., Confortin, A. C. C., Costa, V. G., & Rossi, G. E. (2007). Avaliação de espécies forrageiras de inverno na Depressão Central do Rio Grande do Sul. *Revista Brasileira de Zootecnia*, *36*(6), 1990-1999.

SAS Institute. (2016). *User's guide version 3.5*. Cary, NC: SAS Institute.

Steinwandter, E., Olivo, C. J., Santos, J. C., Araújo, T. L. R., Aguirre, P. F., & Diehl, M. S. (2009). Produção de forragem em pastagens consorciadas com diferentes leguminosas sob pastejo rotacionado. *Acta Scientiarum. Animal Science*, *31*(2), 131-137.

van Soest, P. J., Robertson, J. B., & Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber and nonstarch polysaccharide in relation to animal nutrition. *Journal of Dairy Science*, *74*(10), 3583-3597.

Viana, E. M., & Kiehl, J. C. (2010). Doses de nitrogênio e potássio no crescimento do trigo. *Bragantia*, *69*(4), 975-982.

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